1974

RESEARCH DEPARTMENT

A review of vertical aperture correctors

TECHNOLOGICAL REPORT No. EL-8

UDC 621. 391. 837. 12 1967/32

THE BRITISH BROADCASTING CORPORATION
ENGINEERING DIVISION

RESEARCH DEPARTMENT

A REVIEW OF VERTICAL APERTURE CORRECTORS

Technological Report No. EL-8
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W. Wharton, F.I.E.E.
S.M. Edwardson, M.I.E.E.

Head of Research Department

This Report uses SI units in accordance with B.S. document PD 5686.

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SUMMARY

A vertical aperture corrector for television can be constructed in two basic forms. The first of these uses two delays, each of one television line period, whilst the second uses only one such delay and the signal re-circulates, passing more than once through the delay path. The report compares the two basic forms and discusses their relative advantages and disadvantages in the light of practical requirements. In some cases the subjective performances of each can be considered to be identical, but important applications are found in which only the equipment using two delays fulfils all the requirements. Finally, outline proposals are made summarizing the essential features of practical vertical aperture correctors.

1. INTRODUCTION

The purpose of this report is to discuss the factors which affect the use of vertical aperture correctors for both monochrome and colour television signals. The discussion, which applies to equipment operating on any scanning standard, is an attempt to resolve the difficulty of choosing the most suitable form of vertical aperture corrector for a particular application.

2. BASIC FORMS OF VERTICAL APERTURE CORRECTOR

2.1. General

Two basic forms of vertical aperture corrector are possible. One form is shown in outline in Fig. 1 and requires two line-period delays; the other is shown in Fig. 2 and requires only one line-period delay. In each of these forms of corrector there exists one point (marked P) at which the complete correcting signal is present. In some applications it may be required to introduce a filter at the point P and, since the filter will introduce additional delay of the correcting signal, compensating delay must be introduced elsewhere. In the circuit shown in Fig. 1, compensating delay can readily be introduced at the point Q but in the circuit shown in Fig. 2 the delay of a filter at P can only be compensated by reducing the principal delay from one line-period to one line-period minus T (the filter delay) and introducing additional delays of T at the points A and B.

The introduction of a filter in the path of the correction signal is thus more complicated for the

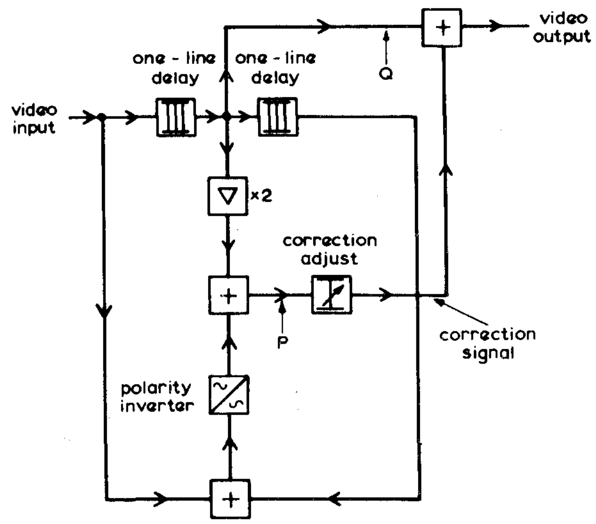

Fig. 1 - Vertical aperture corrector using two one-line delays

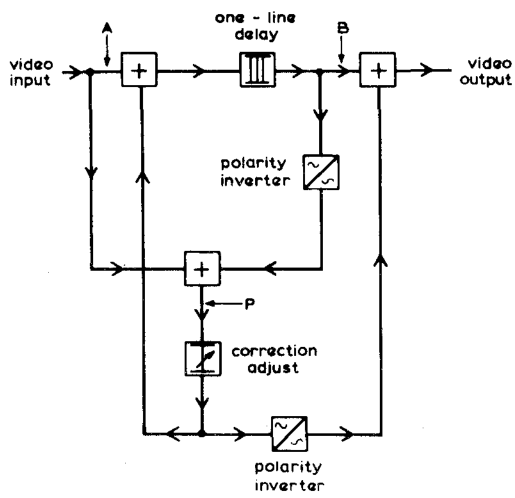

Fig. 2 - Vertical aperture corrector using one-line delay and re-circulation

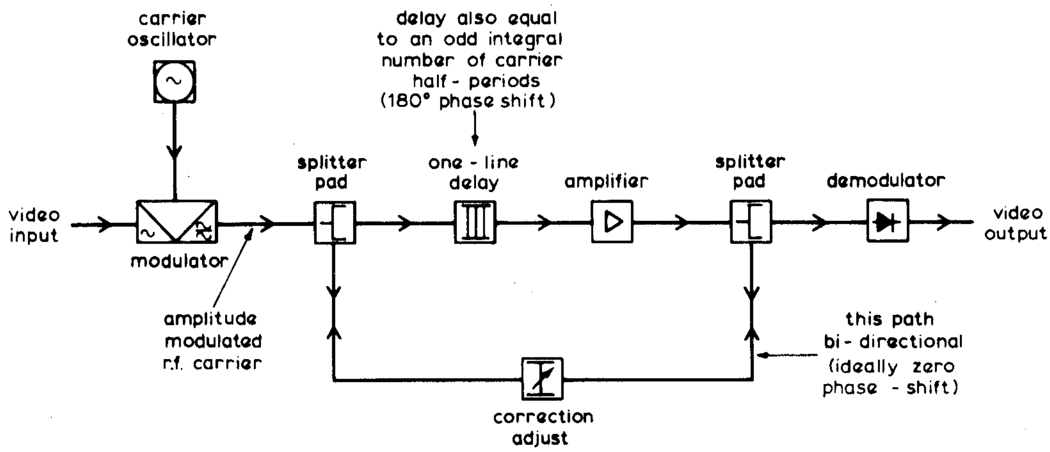

Fig. 3 - Vertical aperture corrector using one-line delay and r.f. re-circulation

circuit using a single line-period delay than for the circuit which uses two line-period delays, particularly when alternative filters are to be selected by a switch. In many cases, however, it is likely that the filter, if one were used, would have pre-determined characteristics and would form a permanent part of the equipment. Compensation for the filter delay could thus be included in the design and a simpler, if less flexible, vertical aperture corrector would result.

In practical vertical aperture correctors the principle delay elements are provided by ultrasonic quartz delays together with r.f. oscillators, modulators and demodulators. An arrangement similar to that shown in Fig. 1 thus employs one modulator and two demodulators, one for each delay, and the signal to be delayed by two line-periods passes from the first to the second delay as a modulated r.f. signal. The one-line, re-circulating vertical aperture corrector, shown in Fig. 2, uses a modulator and demodulator at the input and output of the one-line delay and the re-circulated signal passes twice through these devices. An alternative arrangement has been suggested* whereby the signal processing necessary for vertical aperture correction is carried out using only the r.f. circuits of a one-line re-circulating vertical aperture corrector. Fig. 3 shows the essentials of the method. The whole operation is carried out using a double-sideband amplitude-modulated r.f. signal with the modulator and demodulator at the video input and output points respectively. The delay is equal to one line-period and is also made equal to an odd integral number of r.f. carrier half-periods by a suitable choice of carrier frequency; in passing through the delay, the phase of the signal is thus effectively changed by 180°. An additional path, having effectively zero phase shift and a controlled attenuation, by-passes the delay.

* by P. Rainger, Designs Department.

This path is bi-directional and therefore carries both the undelayed and the re-circulated signals. A short experiment has verified that the performance obtained using this method is similar to that of the conventional one-line vertical aperture corrector shown in Fig. 2. The advantage of the method lies in its simplicity but, in practice, this is offset by the need for very accurate control of the r.f. phase. A further disadvantage, which probably is unimportant in some operational applications, is that the output signal level is dependent upon the amount of correction in use. In comparing the two basic forms of vertical aperture corrector, the arrangement shown in Fig. 3 may be regarded as identical to that illustrated in Fig. 2.

2.2. Choice of Basic Form

It has been shown[1] that the performances of the two basic forms of vertical aperture corrector are subjectively identical for small amounts of correction and there is thus a strong case for the use of the re-circulating form, employing a single one-line delay, wherever the situation permits. Unfortunately, however, the suitability of the re-circulating form of vertical aperture corrector becomes doubtful when large amounts of correction are needed, because vertical "ringing" becomes apparent in such cases. It has been found[1] that the re-circulating form of vertical aperture corrector cannot be used satisfactorily with calibration factors[2] greater than 0·18, corresponding to a maximum amplitude/frequency response (at half line-frequency) of about + 6·5 dB, whereas experience with the plumbicon three-tube colour camera has shown that a typical calibration factor of about 0·29 is required for an associated vertical aperture corrector. This corresponds to more than + 11 dB of correction at half line-frequency and for colour film telerecording it is expected that even greater amounts of correction will be required. Experiments carried out some years ago at Lime Grove, using

the FR3 35 mm monochrome film-telerecording channel, indicated that a substantial amount of vertical aperture correction was desirable; in these experiments, the normal horizontal aperture correction was reduced when using vertical aperture correction so as to preserve a subjectively constant signal-to-noise ratio. The horizontal resolution was thus impaired in exchange for an enhancement of the vertical resolution and it was found subjectively advantageous to use a substantial amount of vertical aperture correction under these circumstances. Unfortunately, these experiments were carried out at an early stage in the development of vertical aperture correction and an accurate record was not made of the amounts of correction used. From a recent examination of the recorded films, however, two conclusions can be drawn.

(i) Some reduction of horizontal resolution in exchange for increased vertical resolution, using a subjectively constant signal-to-noise ratio as a criterion of adjustment, gives a subjectively advantageous result, and

(ii) the amount of vertical correction desirable under these conditions is generally high and is particularly high when a vidicon camera is used as the picture source. It is estimated that in this latter case the required calibration factor was greater than 0·18.

So far it has been assumed that the need for vertical aperture correction in practice will result from insufficient vertical resolution in a known piece of equipment such as a picture signal source, film telerecorder or standards converter. In such cases the requirements are known and can be dealt with. On the other hand, there are circumstances in which the requirements are not known and a fairly flexible vertical aperture corrector would be needed; this could arise, for example, in the case of a signal originating abroad. For such applications, the form of corrector shown in Fig. 1 and employing two one-line delays would be desirable.

To sum up it will be apparent that the use of the re-circulating form of vertical aperture corrector is limited to those cases where:

(i) the amount of vertical correction required is small (i.e. less than that corresponding to a calibration factor of 0·18).

(ii) the requirements are known and the vertical aperture corrector is designed to form an integral and fairly inflexible part of a picture signal source.

The practical needs for either a large amount of correction or flexibility, or both, are thus seen to mitigate against the simpler form of corrector (Fig. 2) employing a single one-line delay. It is assumed, therefore, that most applications will require the use of a corrector of the form shown in Fig. 1 employing two one-line delays.

2.3. Blanking Requirements

Because signal information from successive lines is used to form the output signal, the lines at the beginning and end of each field may contain either uncorrected or spurious signals and to ensure that these do not appear in the output, it is necessary to provide adequate blanking. In most picture signal sources, this will be achieved automatically because the field-blanking pulse applied to the camera (or flying-spot tube) will be narrower than the output field-blanking period and the unwanted information will be removed by the normal blanking operation before the synchronizing pulses are added.

Where vertical aperture correction is to be applied to a composite video signal, however, several additional processes are needed:

(i) The synchronizing pulses must be removed from the input signal.

(ii) A special (extended) field-blanking pulse must be generated, the trailing edge of which extends to a point two line-periods later than the normal beginning of the active field. The number of lines in the active field is thus unavoidably reduced by two. The need for special field blanking is illustrated in Fig. 4.

(iii) After the operation of extended field-blanking has taken place, the synchronizing pulses must be added back to form the output video signal. If it is thought desirable to locate one of the two additional blank lines of each field at the top of the picture and the other at the bottom, the timing of the synchronizing pulses may be delayed by one line.

3. APPLICATIONS OF VERTICAL APERTURE CORRECTORS

3.1. Picture Signal Sources

A vertical aperture corrector which could be inserted in the path of the composite monochrome or colour video signal would offer an economic advantage; one corrector could then serve a number of picture sources. However, there are disadvantages in such an arrangement since not all picture

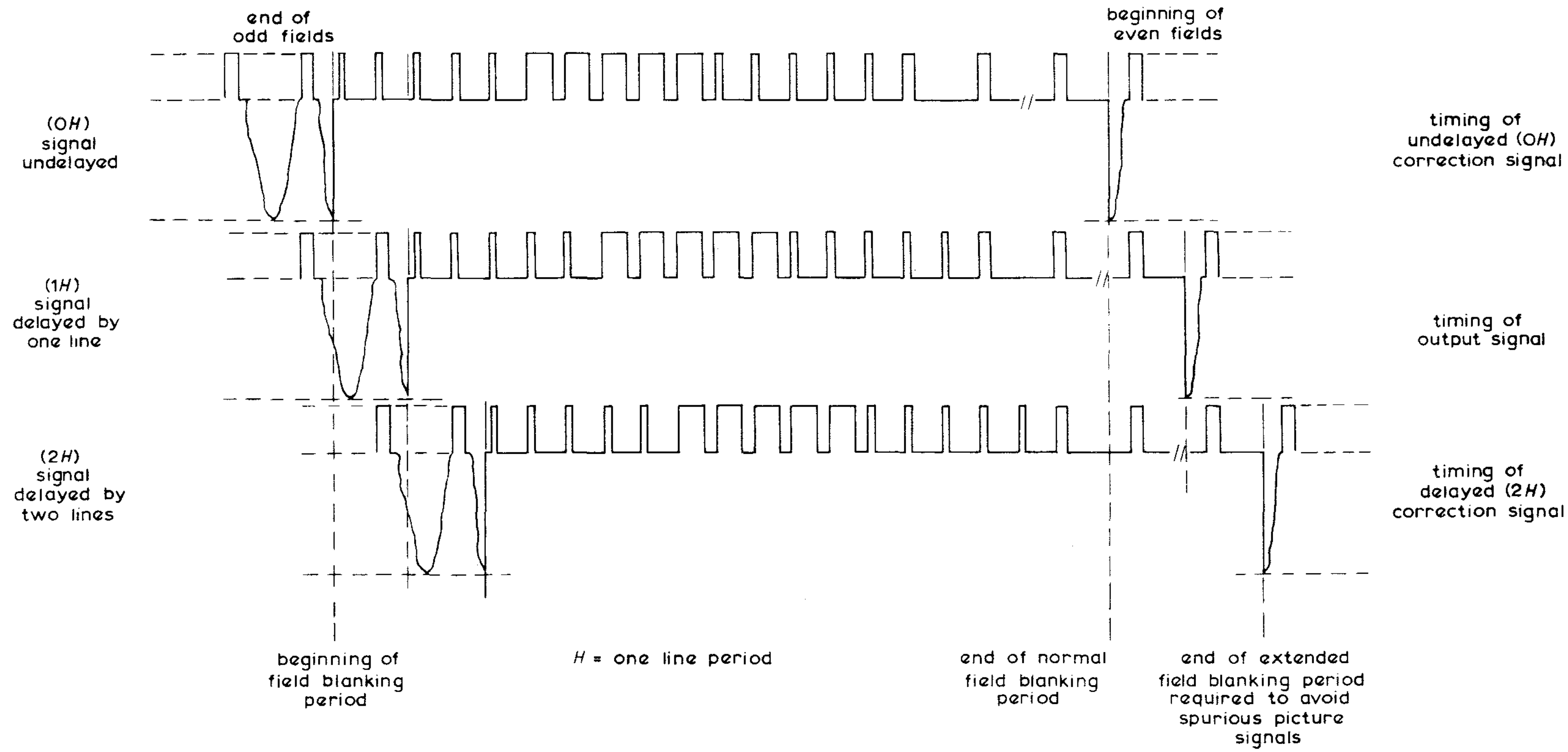

Fig. 4 - Waveforms showing relative timings of output and correction signals during one field-blanking period

Note: In the blanking interval between even and odd fields similar blanking requirements apply

sources require the same amount of correction. In addition, the design of apparatus which will correct a composite colour video-signal and at the same time deliver a completely standard output signal presents some difficulty, because the process of vertical aperture correction may produce spurious signals below black-level and it is difficult to remove these signals without distortion of the colour burst. The difficulty could be overcome but, in view of the operational disadvantages, it is considered that a very useful arrangement would be to fit a vertical aperture corrector to the colour coder of each picture source. One way in which this could be achieved would be to apply vertical aperture correction to the luminance signal before the addition of the modulated colour sub-carrier; an arrangement suitable for use with a three-tube colour camera is shown in Fig. 5. A vertical aperture corrector would thus form a part of the coder associated with each colour picture source and the same type of corrector could also be used for normal monochrome picture sources.

An alternative way in which a vertical aperture corrector could be used with a three-tube colour picture signal source has been proposed.[3] In this proposal* vertical (and horizontal) correction signals, derived from the linear** green (G) picture signal alone, are added equally to the linear R, G and B signals prior to further processing. Since the vertical aperture corrector is placed in the green channel, the green picture signal is delayed by one line-period relative to the red and blue picture signals and to avoid the need for further delays in the red and blue channels the images formed on the red and blue camera tubes are mis-registered in order to compensate the errors. It is of interest to note that one advantage of this alternative proposal is to make the effective resolution of a three-tube camera less dependent on the registration of the three tubes.

* Known as the "contours-out-of-green" method.
** Proportional to scene brightness.

The forms of vertical aperture corrector proposed in this report could be either inserted in the luminance channel of a colour coder or used for the "contours-out-of-green" method.

3.2. Other Cases

In addition to the correction of picture signal sources, other applications are likely in which a monochrome signal originates from a remote source and is received as a composite video signal. In these cases it would be necessary to carry out additional processes such as the removal of the synchronizing pulses and the insertion of extended blanking pulses as described in Section 2.3.

However, the vertical aperture correction of a composite colour video signal is only likely to be needed when receiving a signal from abroad. If the input from abroad conformed to a standard other than 625-line PAL, the vertical aperture correction could be inserted in the luminance channel of the transcoding equipment in a manner similar to that proposed for colour signal sources and shown in Fig. 5. If transcoding were otherwise unnecessary, however, it is doubtful whether vertical aperture correction would be worthwhile because of the impairment of picture quality which would result from the additional signal processing.

4. PROPOSED FORMS OF VERTICAL APERTURE CORRECTORS

As has been discussed in Section 2, either of the two forms of vertical aperture corrector may be

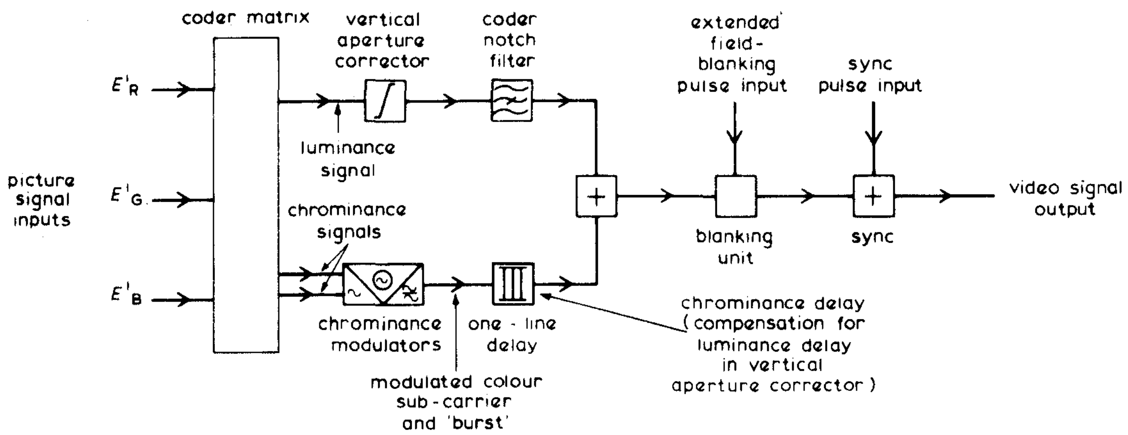

Fig. 5 - Vertical aperture correction of luminance component of colour signal during coding

chosen although it is expected that the re-circulating form employing a single one-line delay will find only limited application. Block schematic diagrams giving more details of the two forms of proposed corrector are shown in Figs. 6 and 7. In Fig. 6, which shows the re-circulating form, it will be seen that a delay of T seconds in the correction-signal path has been accommodated by using a principal delay of one line-period minus T seconds together with two compensating delays as described in Section 2.1. In Fig. 7, a form of vertical aperture corrector employing two line-period delays is shown which enables any one of three filters to be inserted in the correction-signal path, the time delay caused by the filter being compensated by a corresponding delay inserted in the main-signal path.

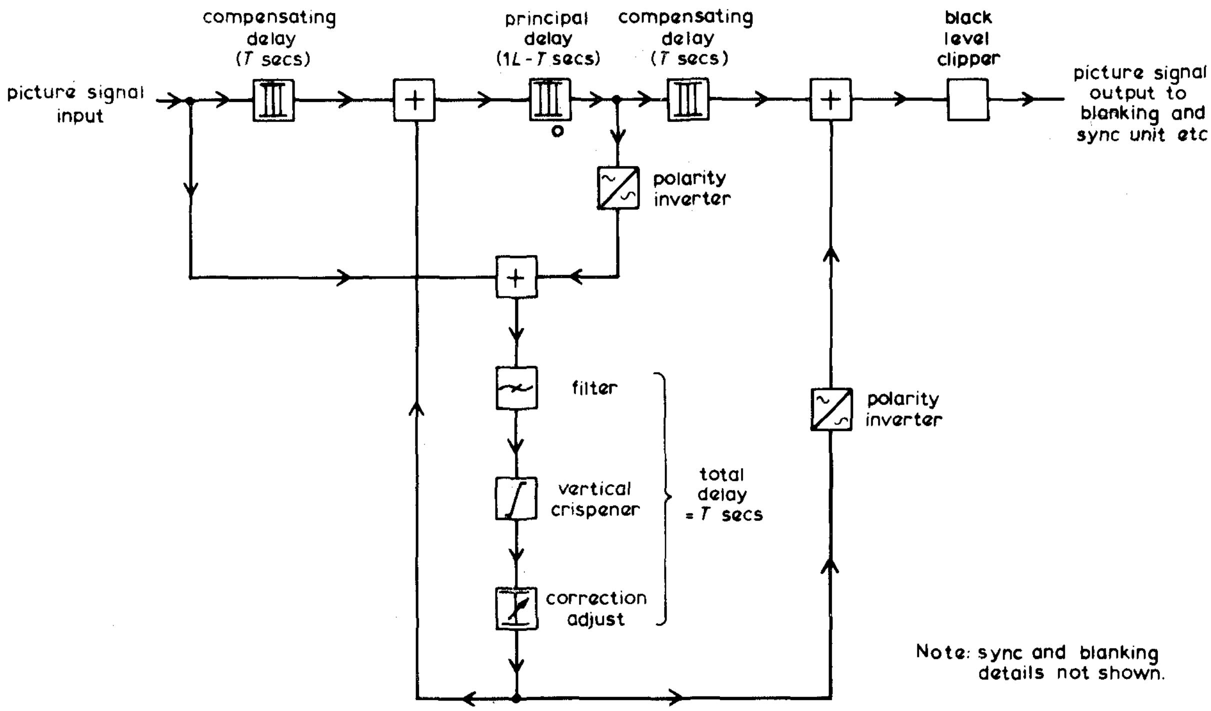

Fig. 6 - Proposed vertical aperture corrector using one-line delay and re-circulation

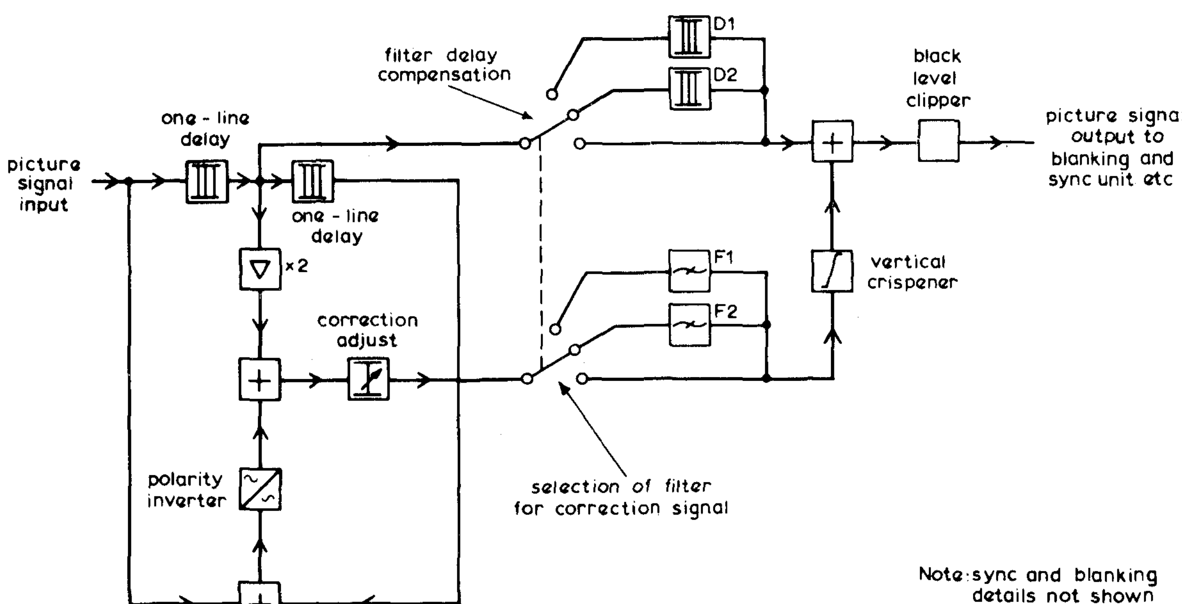

Fig. 7 - Proposed vertical aperture corrector using two one-line delays

5. CONCLUSIONS

Apart from the differences already discussed, the two proposed correctors have much in common and the following conclusions apply to both:

(a) Both forms of corrector shown are suitable for insertion in the output of a monochrome picture source prior to blanking and the addition of synchronizing pulses.

(b) Both are suitable for insertion in the luminance channel of a transcoder or the coder associated with a colour picture signal source (Fig. 5) or for use in the "contours-out-of-green" arrangement. This assumes that equipment would be designed or modified specifically to allow the insertion of the vertical aperture corrector. With reference to Fig. 5, it should be noted that when a vertical aperture corrector is inserted in the luminance signal path, a compensating delay of one line-period must be inserted in the chrominance channel in order to achieve correct registration of the luminance and chrominance signals.

(c) Low-pass filters (together with the necessary compensation) can be incorporated when it is desired to minimize the increase in noise due to the correction process. However, the necessary compensation is inflexible in the case of the re-circulating form of vertical aperture corrector.

(d) A circuit should be included which removes excursions of the signal below black level. This is desirable since experience has shown that these excursions can cause difficulties in the operation of other equipment; in particular, the operation of video tape recorders may be disturbed.

(e) A vertical crispener circuit[4] may be included in the correction-signal path which will result in correction without the addition of noise in large picture areas at the expense of zero correction in areas of low contrast vertical detail.

6. REFERENCES

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Printed by BBC Research Department, Kingswood Warren, Tadworth, Surrey